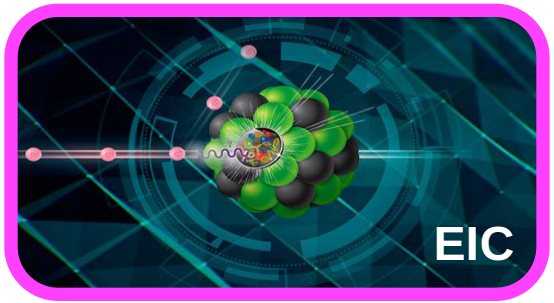
4-year overview



Ramona Vogt for LLNL

January 10, 2025

Groups members: current and past

Graduate students: NA

Postdocs

current: Ben Gilbert

previous: E- Dhanush Hangal (staff LLNL), Qipeng Hu (Prof. Univ S&T China)

previous: T - Vincent Cheung (staff LLNL)

Undergrads

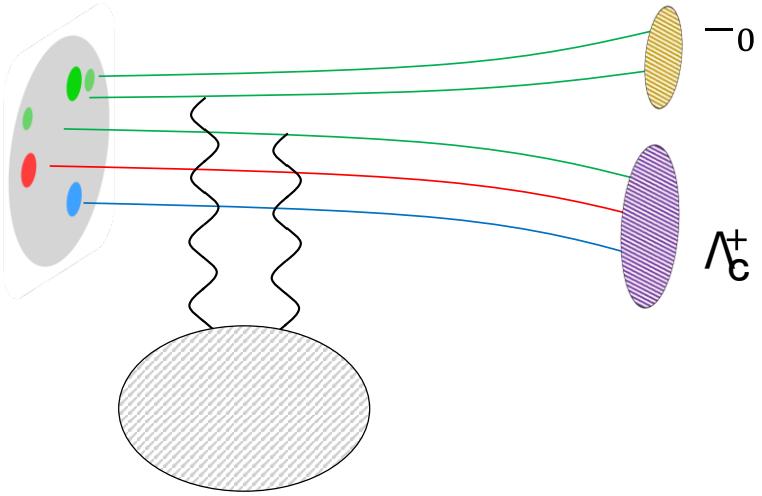
current:

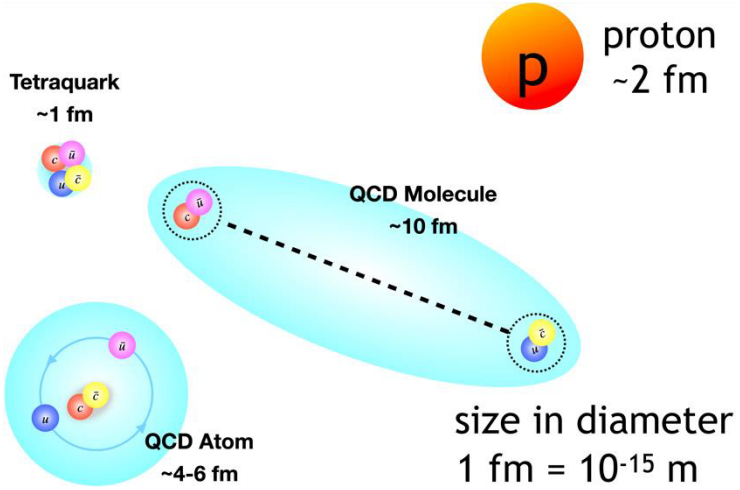
previous: Luis Garabito (MSU), JiaJun Huang (UCR), Mia Macias (UCR), Chase Own (CSU)

Staff: Ron Soltz, Dhanush Hangal, Ramona Vogt, Vincent Cheung

Leveraged funding

- We have been able to contribute to the theory effort thanks, in part, to LDRD funding
  - The Incredible Shrinking Proton (FY21-FY22), Ramona Vogt (PI), hired Vincent Cheung
  - Do Tetraquarks exist? Understanding the nature of the mysterious X(3872) (FY23-FY24), Vincent Cheung and Dhanush Hangel (co-PIs)





Main accomplishments in past 4 years

- LLNL experimental EIC activity is comprised entirely from undergraduate student activities.
  - ZDC studies
  - Application of AI/ML techniques to detector calibration.
- Theory activity is based on the two LDRDs which have made our participation possible
  - Intrinsic charm studies at fixed-target interactions – predictions for SeaQuest at FNAL and SMOG at LHCb
  - Predictions of charm tetraquark production by intrinsic cham – both mass and kinematic distributions, production by this mechanism suggests that the molecular type state is more closely bound than 4-independent quarks and antiquarks in the tetraquark state
  - Quarkonium production was studied in e+p collisions for the first time in the ICEM

Detector construction plans at campus/lab

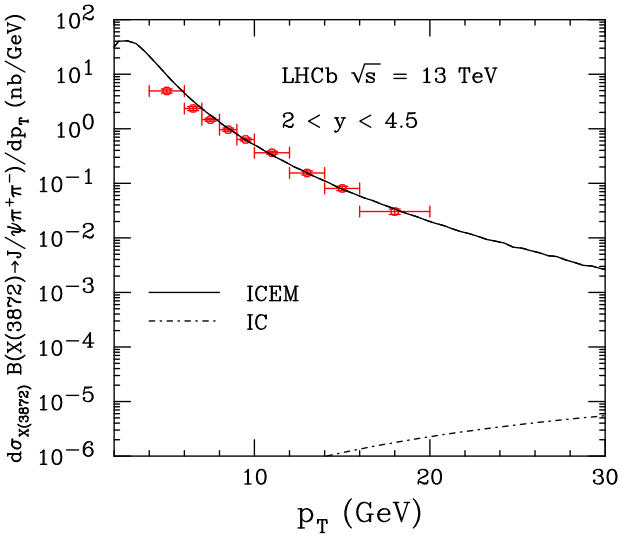
- None foreseen

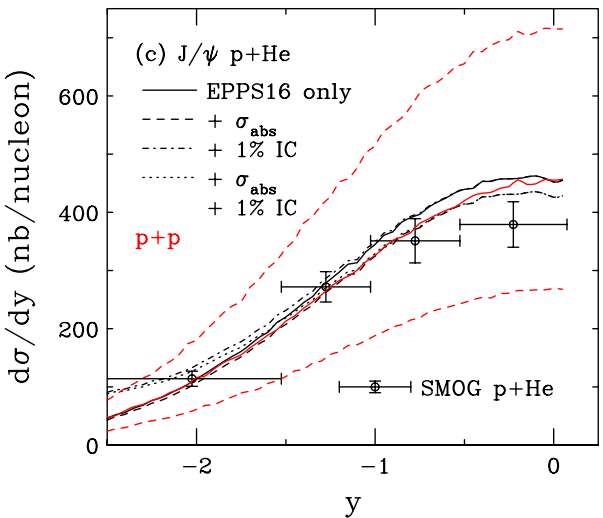
Key roles in ePIC

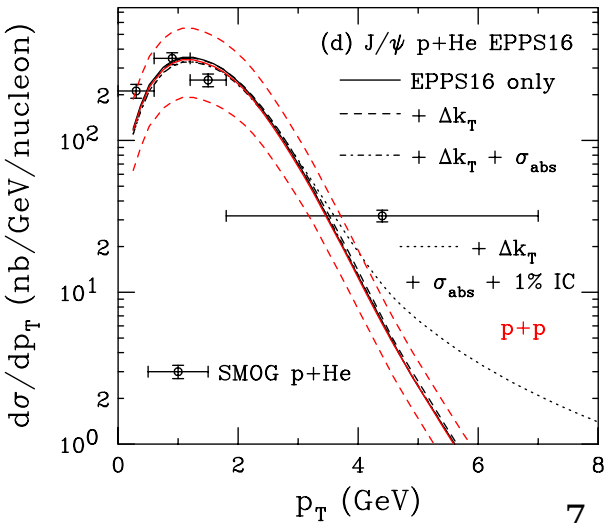
- Future:
  - jets and heavy flavor detector simulations
  - physics performance
- Current research:
  - ATLAS
    - Hangal is jet sub-convener
    - Gilbert is UPC sub-convener
  - sPHENIX

Key non-EIC accomplishments

- Experimental accomplishments:
  - Study of jet quenching vs. R_g,
  - jet-quenching vs. centrality with correlated errors
- Theoretical accomplishments:
  - First calculation of tetraquarks in the intrinsic cham model (left)
  - Excellent comparison between SMOG data and model calcuations (middle, right)

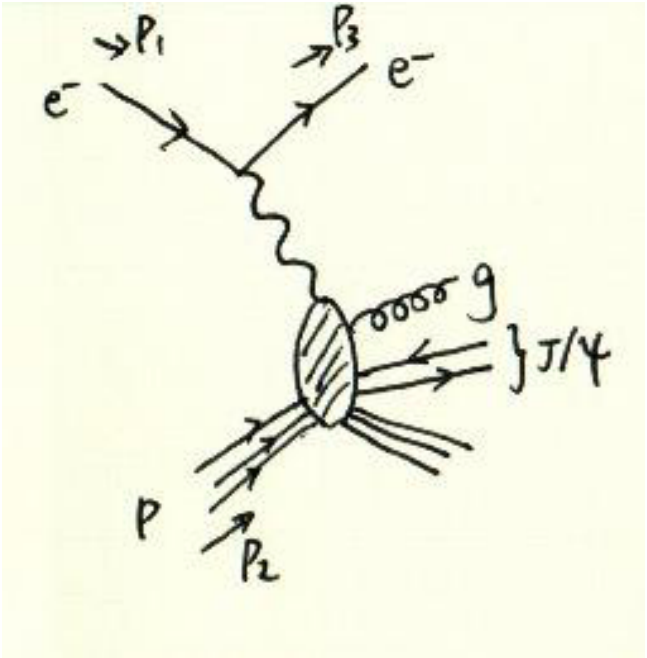






J/ψ Photoproduction in the ICEM

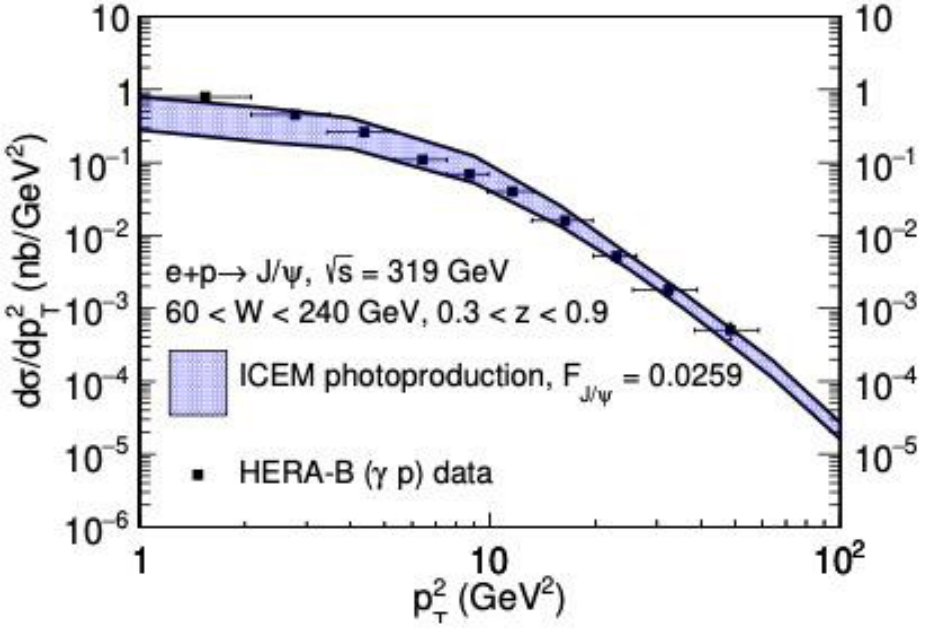
- The improved color evaporation model (ICEM) allows differentiation between quarkonium states
- The ICEM was further improved by Cheung and RV by calculating polarization but, until work began with the consortium, it had not yet been applied to e+p collisions, only p+p interactions
- The first calculations of the ICEM for e+p were compared to low Q^2 data taken at HERA [EPJC 68, 401 (2010)]
- Simpler than in p+p collisions, only spin triplet combinations are taken into account to compute the cross section



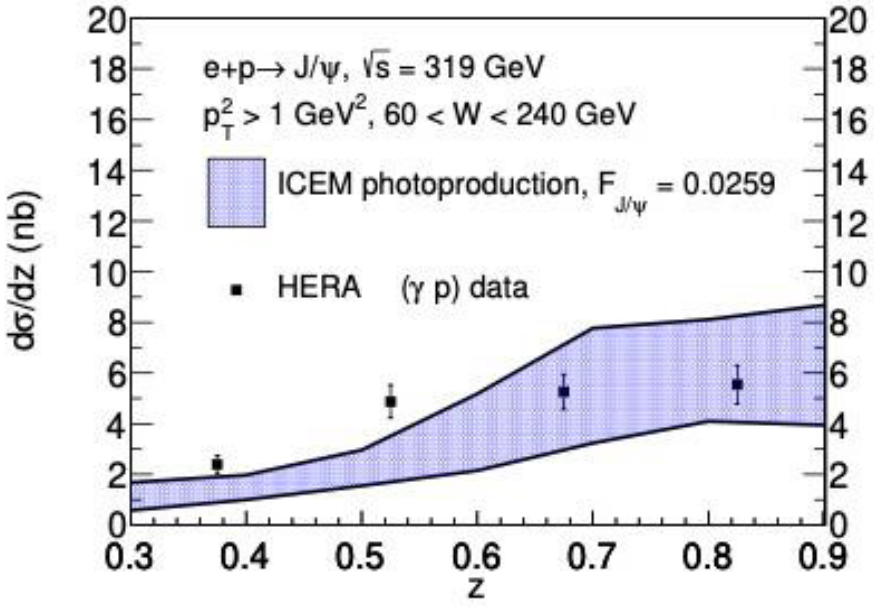
Unpolarized cross sections

Unpolarized cross section is calculated as the sum of polarized cross sections

p_T^2 distribution



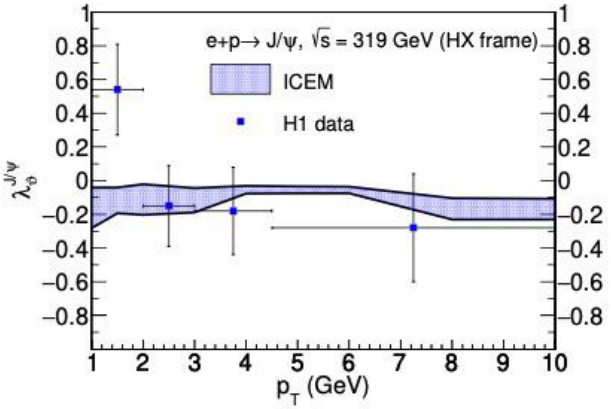
z distribution

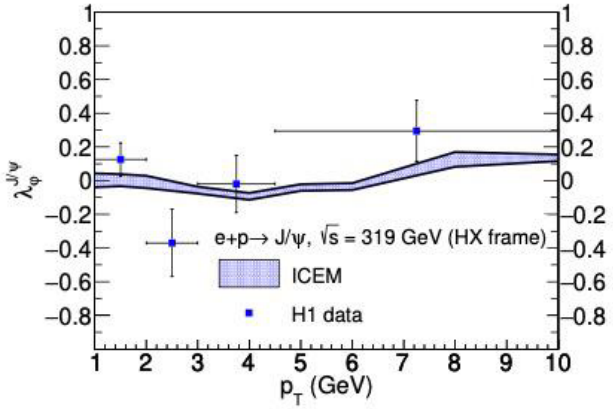


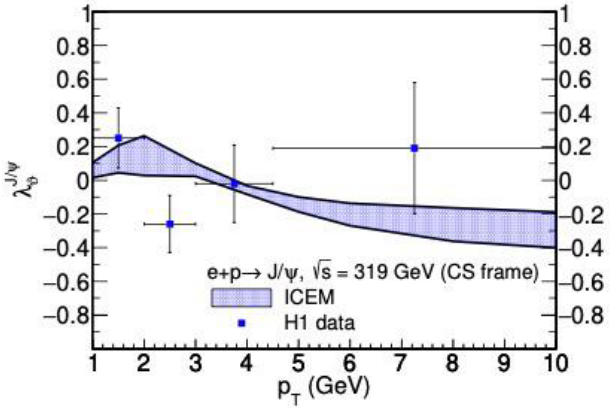
Polarization coefficients

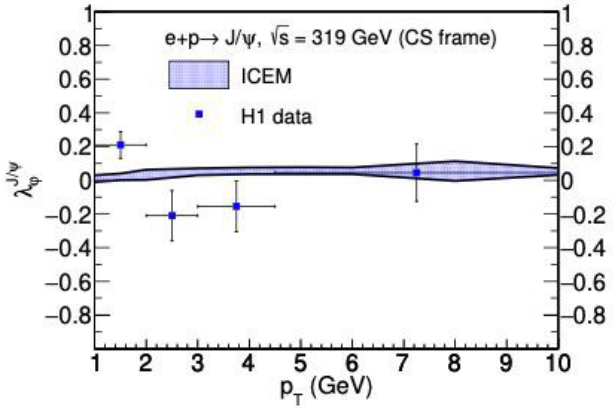
Left: polar anisotropy; Right: azimuthal anisotropy

Top: helicity frame; Bottom: Collins-Soper frame









Publications in past 4 years

- Direct quarkonium production in DIS from a joint CGC and NRQCD framework, Cheung, Kang, Salazar and Vogt, Phys. Rev. D 110, 049039 (2024)
- Physics case for quarkonium studies at the Electron-Ion Collider, review to be published in Prog. Part. Nucl. Phys., Cheung and Vogt were contributors, arXiv:2409.03691 [hep-ph]
- J/ψ photoproduction and polarization in e+p collisions in the improved color evaporation model, Cheung and Vogt, Phys. Rev. D 110, 094026 (2024)

Future theory plans related to the EIC

- Calculations in ICEM extended
  - J/ψ e+p calculations will be extended to predictions for EIC
  - Feed down from excited states will be included
  - Upsilon production and polarization will also be calculated
- ICEM + intrinsic charm calculations will be made for the EIC

Backup